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EXHAUST GAS ENERGY RECOVERY DEVICE  
[Abgasenergie-Rueckgewinnungseinrichtung]

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The invention relates to an exhaust gas energy recovery device according to the preamble of Claim 1.

The invention relates especially to an exhaust gas energy recovery device with a power turbine with which excess flow energy of the exhaust gases of an internal combustion engine is converted into mechanical energy and then is supplied as useful power to the internal combustion engine. These exhaust gas energy recovery devices are known under the name "Power Take In" and the corresponding abbreviation "P.T.I.".

Two types of exhaust gas energy recovery devices are known from practice. In one type there is no fluid clutch, but instead a toothed clutch which can be shifted only when the turbine and internal combustion engine are at rest. When the toothed clutch has been opened, the planetary gearing can be blocked against the gear housing and thus rotation can be prevented. This prevents the turbine from running away with the toothed clutch opened and exploding at overly high rpm. The disadvantages of this type are that torsional vibrations of the internal combustion engine are transmitted undamped to the planetary gearing and the gas turbine, that when exhaust gas supply is interrupted the gas turbine is driven by the crankshaft of the internal combustion engine, therefore from the rear, and that the gas turbine can be decoupled only when the engine is at rest. The invention does not relate to this type, but to the other type which has a fluid clutch in the recovery line. In the known embodiment there is no mechanical clutch between the gas turbine and the crankshaft of the internal

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\* Numbers in the margin indicate pagination in the foreign text.

combustion engine, but there is a fluid clutch which is continuously filled with oil which can transmit essentially identically high torques in the forward direction of rotation and the backward direction of rotation. The fluid clutch can damp torsional vibrations of the gas turbine and of the internal combustion engine. This known type of energy recovery device however has the disadvantages that even when the exhaust gas supply to the gas turbine is interrupted the internal combustion engine entrains the fluid clutch and the planetary gearing as well as the gas turbine, i.e., drives them from the rear with the full torque of the fluid clutch. In the case of a defect of one of the components in the recovery line from the exhaust gas turbine to the crankshaft of the internal combustion engine, it is, however, desirable to decouple the recovery line from the internal combustion engine so that operation of the internal combustion engine to drive the motor vehicle can be maintained. But if a gas valve or gas spool valve which controls the supply of exhaust gas to the gas turbine is partially or completely opened when the fluid clutch has been emptied the gas turbine passes to explosive rpm within an extremely short time and thus it endangers the personnel in the engine room and the other components of the exhaust gas energy recovery device and of the internal combustion engine. Experience discloses that the gas valves or gas spool valves can be completely closed only when new. Furthermore, there are also embodiments in which for thermal reasons the gas spool valve in the closed state keeps a small opening open and thus allows a certain amount of gas to pass through. In both cases, the turbine wheel of the fluid clutch is caused to rotate.

The object of the invention is to make the exhaust gas energy

recovery device such that the advantages of a fluid clutch are fully maintained, but nevertheless the drive connection in the recovery device is interrupted, for example the fluid clutch can be completely emptied, without the danger of the gas turbine overspeeding.

This object is achieved as claimed in the invention by the characterizing features of Claim 1.

The invention prevents uncontrolled acceleration of the gas turbine by its being held by the blocking device when the gas turbine is decoupled from the drive line of the internal combustion engine, for example by emptying the liquid clutch. The blocking device can be a mechanical brake or a clutch, for example a toothed clutch. A toothed clutch can however only be actuated when the gas turbine stops completely after emptying the fluid clutch. To do this, it is necessary for a gas spool valve in the exhaust gas supply line to the gas turbine to close tightly, in a manner which is completely impassable to the gas. Conversely, a brake for blocking the gas turbine can also be actuated when the gas turbine is still turning. The blocking device is in the drive connection between the gas turbine and the fluid clutch. The invention also ensures that the fluid clutch is always completely filled as long as the gas supply to the gas turbine is completely or partially opened.

The invention fully maintains the damping behavior of the liquid clutch and the resultant decoupling of torsional vibrations between the crankshaft of the internal combustion engine and the planetary gearing. With the fluid clutch emptied there is the advantage that the crankshaft of the internal combustion engine does not entrain the planetary gearing and the exhaust gas turbine. The fluid clutch can

have flow blades arranged obliquely in the conventional manner in order to increase the transmittable torque and to reduce it in the opposite drive direction.

As claimed in the invention, there is a control device which ensures that the exhaust gas supply to the gas turbine is interrupted below a certain oil feed rate or a certain oil pressure in the oil supply line to the fluid clutch and that the exhaust gas supply can only be opened if the fluid clutch is being supplied with a minimum amount of oil. With the blocking device, preferably a brake, a simple construction is achieved when the primary part of the fluid clutch can be connected to a stationary housing using it. The blocking device can preferably be actuated from outside the stationary housing without the housing having to be dismantled. The blocking device can be actuated by hand or automatically, depending on the oil supply of the fluid clutch. The stationary housing accommodates preferably the planetary gearing, the blocking device and the fluid clutch, so that these components together can be mounted and dismantled as a unit.

The invention is described below with reference to the drawings using one preferred embodiment as an example.

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The exhaust gas energy recovery device shown in the drawings contains, arranged in the following sequence in succession and connected to one another in terms of propulsion, a gas turbine 2, planetary gearing 4, a mechanical blocking device 6 in the form of a mechanical brake, a fluid clutch 8 with a primary part or pump wheel 10 and with a secondary part or turbine wheel 12, main gearing 14 and an elastic clutch 16. The elastic clutch 16 is connected to the crankshaft 18 of an internal combustion engine 20. An exhaust gas feed line 22

connects the exhaust gas line 24 of the internal combustion engine 20 to the gas turbine 2 and contains a valve 26, preferably in the form of a spool valve. The planetary gearing 4, the fluid clutch 8, the main gearing 14, and the brake 6 are accommodated in a common housing 28 and together with the housing 28 can be replaced as a unit. The housing 30 of the gas turbine 2 which is provided with a gas outlet 32 is attached to the housing 28.

An oil feed line 34 which contains a pressure measuring device 36 or a flow measuring device and which supplies oil from the internal combustion engine 20 to the fluid clutch 8 is connected to the secondary part 12 of the fluid clutch 8. The pressure measuring device or flow measuring device 36, depending on the oil pressure or the oil flow rate, delivers signals to an electronic control unit 42 which is also connected via electric lines 44 to the valve 26 in the exhaust gas feed line 22 and then closes this valve 26 and does not allow it to open again if the oil pressure or the oil supply rate in the oil feed line 34 is below a certain minimum value. The fluid clutch near its outer periphery 33 is provided with a flow throttle outlet opening 52 via which some oil continuously flows out throttled during operation and thus slip heat is dissipated. The fluid clutch 8 can be emptied by way of the same flow throttle outlet opening 52 when the oil supply by way of the oil feed line 34 is interrupted.

The mechanical blocking device 6 can be actuated by hand from outside the housing 28. It is moreover connected to the electronic control unit 42 by way of electric lines 54 so that the blocking device also automatically blocks the primary part 10 of the fluid clutch 8 with the housing 28 and thus prevents rotation when the oil supply or

oil pressure in the oil feed line 34 drops below the indicated minimum value. The gas turbine or power turbine 2 is driven by the exhaust gases of the internal combustion engine 20 after the valve 26 has been opened. The output rpm of the gas turbine 2 on its turbine shaft 60 is reduced by the planetary gearing 4. In the normal operating state, the fluid clutch 8 is filled with oil and the gas turbine 2 is connected to the crankshaft 18 of the internal combustion engine 20 by way of the fluid clutch 8. This applies both to output operation in which the driving power is transmitted from the gas turbine 2 to the crankshaft 18, and also to idling of the gas turbine 2 in which the valve 26 of the exhaust gas feed line 22 is closed and therefore the gas turbine 2 is driven on the output side by the crankshaft 18 via the fluid clutch 8. Only in the case of a malfunction are the planetary gearing 4 and the gas turbine 2 separated from the crankshaft 18 of the internal combustion engine 20 by emptying the fluid clutch 8, and for safety reasons the output shaft 60 of the gas turbine 2 is held by the blocking device 6 via the primary part 10 of the fluid clutch 8 and the planetary gearing 4, and thus prevented from rotating.

As claimed in the invention, the gas turbine 2 can be decoupled from the internal combustion engine 20 by emptying the fluid clutch 8 while the internal combustion engine 20 is running. The fluid clutch 8 is automatically emptied via the flow throttle outlet opening 52 when the oil supply via the oil feed line 34 is interrupted by the valve 62 contained in it. The electronic control unit 42 causes the valve 26 in the exhaust gas feed line 22 to be closed as soon as the oil supply rate or the oil pressure in the fluid clutch 8 drops below a certain minimum value. In a normal disconnection process first the valve 26 of

the exhaust gas feed line 22 is closed by the electronic control unit 42, before the oil supply in the oil feed line 34 is interrupted by way of the valve 62. The oil feed line 34 is preferably connected to the lubricating oil circuit of the internal combustion engine 20.

## Claims

1. Exhaust gas energy recovery device with a gas turbine which can be driven by the exhaust gases of an internal combustion engine and with a fluid clutch which can be driven by way of planetary gearing in order to supply the exhaust gas energy to the drive line of the internal combustion engine, characterized in that there is a blocking device (6) for blocking of the gas turbine (2) in order to prevent the gas turbine from overspeeding when the fluid clutch (8) is empty or not completely full.

2. Exhaust gas energy recovery device as claimed in Claim 1, characterized in that the blocking device is connected to the primary part (10) of the fluid clutch and can block this primary part (10).

3. Exhaust gas energy recovery device as claimed in Claim 1 or 2, characterized in that the blocking device (6) is a mechanical brake.

4. Exhaust gas energy recovery device as claimed in one of Claims 1 to 3, characterized in that there is a control device (42, 36, 62) which ensures that the exhaust gas supply (22) to the gas turbine (2) is interrupted below a certain minimum oil pressure or minimum oil supply amount in the feed line (32) to the fluid clutch (8), and that the exhaust gas supply (22) can only be opened when the minimum value is reached.

5. Exhaust gas energy recovery device as claimed in one of Claims 1 to 4, characterized in that the fluid clutch (8) is a type which can produce higher output torque in the drive direction from the primary part (10) to the secondary part (12) than in the opposite drive direction from the secondary part (12) to the primary part (10).

6. Exhaust gas energy recovery device as claimed in one of Claims

1 to 5, characterized in that the primary part (10) of the fluid clutch (8) with the stationary housing (28) can be blocked by the blocking device (6).

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7. Exhaust gas energy recovery device as claimed in Claim 6, characterized in that the blocking device (6) can be actuated from outside of the stationary housing (28) without the housing having to be dismantled.

8. Exhaust gas energy recovery device as claimed in Claim 6 or 7, characterized in that the housing (28) accommodates the planetary gearing (4), the blocking device (6), and the fluid clutch (8) which form an interchangeable unit with this housing.

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1 page of drawings attached  
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